Hydrographic Conditions in the Southern Gulf of St. Lawrence During July 26 - August 3, 1982

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Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

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by

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ABSTRACT

Drinkwater, K., G. Taylor, and L. Petrie. 1985. Hydrographic conditions in the southern Gulf of St. Lawrence during July 26-August 3, 1982. Can. Tech. Rep. Fish. Aquat. Sci. 1338: iv + 29 p.

Measurements obtained in July-August, 1982, show the temperature and salinity of the surface layer waters in St. Georges Bay, Nova Scotia, were similar to those over the Magdalen Shallows south of 47°N latitude and north and east of Prince Edward Island but the salinities were higher by 1 to 1.5 psu (practical salinity units) than the waters in eastern Northumberland Strait. Surface layer temperatures decreased and salinities increased towards the Laurentian Channel. Waters of <1°C found below ~35 m over the Magdalen Shallows and in the Laurentian Channel had salinities of 31.5 to 32 and 32.5 to 33, respectively. This salinity difference reflects localized 'in situ' cooling in winter. In 1982 the salinities throughout the region were higher by 1 to 1.5 psu than those measured two weeks earlier in the year in 1981. It is proposed that this was due to a later and slightly reduced run-off from the St. Lawrence River system in 1982.

RÉSUMÉ

Drinkwater, K., G. Taylor, and L. Petrie. 1985. Hydrographic conditions in the southern Gulf of St. Lawrence during July 26-August 3, 1982. Can. Tech. Rep. Fish. Aquat. Sci. 1338: iv + 29 p.

Des mesures effectuées en juillet-août 1982 montrent que la température et la salinité des eaux de la couche superficielle dans la baie de St. Georges (Nouvelle-Écosse) ressemblaient à celles qui règnent sur le banc Magdalen, situé un peu au sud du 47e parallèle N et au NE de l'île du Prince-Édouard, mais que les salinités étaient supérieures de 1 à 1,5 psu (practical salinity units ou unités pratiques de salinité) à celles des eaux de l'est du détroit de Northumberland. Les températures de la couche superficielle diminuaient, tandis que les salinités augmentaient au fur et à mesure qu'on se rapprochait du chenal Laurentien. Les eaux < 1°C trouvées par plus de ~35 m sur le banc Magdalen et dans le chenal Laurentien avaient des salinités respectives de 31,5 à 32 et de 32,5 à 33. Cette différence de salinité reflète des refroidissements in situ localisés en hiver. En 1982, les salinités sur l'ensemble de la région étaient supérieures par 1 à 1,5 psu à celles qui avaient été mesurées deux semaines plus tôt à l'époque correspondante de 1981. Les auteurs estiment que ceci s'expliquait par un ruissellement à la fois tardif et légèrement moins abondant, en provenance du bassin hydrographique du Saint-Laurent en 1982.

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INTRODUCTION

This report describes temperature, salinity and density (sigma-t) data collected during a multi-disciplinary cruise into the southern Gulf of St. Lawrence during late July-early August, 1982. One of the main objectives of the cruise was to compare biological and physical properties in St. Georges Bay with those of the southern Gulf. The Bay had been studied extensively during the 1970's (see bibliography in Lambert 1980, also Hargrave et al. 1984) and we wished to know if conditions there were representative of a wider area. An earlier cruise with similar objectives was undertaken during July, 1981 (Drinkwater et al. 1983). At that time the physical properties of the surface layer waters in St. Georges Bay were identical to those found nearshore (within approx. 10 km) along the coastlines of mainland Nova Scotia to the west and Cape Breton Island to the northeast, but were 1 to 2°C warmer and higher in salinity by 1 to 1.5 psu (practical salinity units) than the surface waters of Northumberland Strait between the Bay and Prince Edward Island (P.E.I.). The 1982 cruise was undertaken in an attempt to confirm the results obtained in 1981 and secondly to extend the areal coverage of the measurements.

As on the earlier cruise, time series measurements over a period greater than 24 hr were obtained at two stations, one in St. Georges Bay and the other on the Magdalen Shallows. These are labelled as 'tidal' stations in Fig. 1. Measurements were also obtained at a grid of stations covering an area from St. Georges Bay to beyond the northern tip of Cape Breton Island and across to the Magdalen Islands (Fig. 1).

Temperature and salinity data were collected at all stations using a continuous profiling Guildline CTD. Salinities in the text are reported in the Practical Salinity Scale 1978 (Lewis 1980). Water densities were determined from

the temperatures and salinities using the UNESCO 1980 formulation and are expressed in sigma-t (σ_t) units.

The hydrographic conditions during the 1982 cruise are described below, followed by a discussion of the data including a comparison between the 1981 and 1982 results.

HYDROGRAPHIC CONDITIONS

TIME SERIES DATA

A time series of hydrographic measurements was obtained at one station located in St. Georges Bay (31 h during July 26-28) and at another located approximately 30 km southeast of the Magdalen Islands (38 h during August 1-3).

In St. Georges Bay the surface layer was ~ 15 m deep with temperatures > 17°C and salinities < 30 (Fig. 2). Below the surface layer, temperatures decreased gradually to < 8°C near bottom (34 m) while salinities were ~ 30.5. Sigma-t values decreased by ~ 2 units between the surface layer and near bottom. No significant changes in the vertical structure were observed over the duration of the measurements.

Off the Magdalen Islands the surface layer was cooler (13 to 15°C), more saline (~ 30.5) and shallower (10 m) than in St. Georges Bay (Fig. 3). The vertical temperature gradient was more diffuse (see Fig. 2,3) and the near-bottom water was colder (3 to 6°C) and of higher salinity (31.7). The lower bottom temperatures were primarily due to the deeper depths. The higher salinities throughout the water column at the Magdalen Islands station reflect the influence of offshore water to the northeast (see discussion below). The warmer (> 15°C), lower salinity (< 30.5) water observed during the last twelve hrs on August 1 suggests an intrusion from the area south of the Magdalen Islands.

SPATIAL VARIABILITY

The station grid consisted of six transects and a total of 59 stations (Fig. 1). Transect A ran north from St. Georges Bay towards the Magdalen Islands. Transects B, C and D crossed northwestward from western Cape Breton Island to the Magdalen Islands. Station C11 was located mid-way between the western most stations along transects C and D. Transect E extended ~ 70 km northward from the tip of Cape Breton Island across the Magdalen Shallows then dog-legged to the east into the deep waters (> 200 m) of the Laurentian Channel. The nearshore stations along transects C to E sampled water within the Cape Breton Channel, a relatively deep (> 100 m) topographic feature which cuts the Magdalen Shallows immediately offshore of northern Cape Breton Island (see Fig. 1). Transect F crossed from the northern tip of Cape Breton Island into the Laurentian Channel then jogged north and west.

Vertical profiles of the temperature, salinity and σ_t along the transects or a portion of their length are plotted in Figures 4 to 12. Horizontal contour plots of these same variables at depths of 5, 25, and 50 m are shown in Figures 13 to 21.

The surface layer in St. Georges Bay and over the Magdalen Shallows south of 47°N was warm (17 to 19°C) and roughly 15 m deep (Fig.4-6). Surface salinities were 29 to 30 except off the eastern tip of P.E.I. where they were 27 to 29 (Fig. 4). North of approximately 47° latitude surface temperatures decreased (Fig. 13). Between transects C and D, a distance of 40 km, temperatures dropped 2°C and by transect E, a further distance of ~30 km, they decreased an additional 2 or 3°C to 12 to 14°C. The surface layer temperatures in the Laurentian Channel were near 10°C. Although a decrease in surface temperature northeastward from P.E.I. is normal (Weiler and Keeley 1981), the gradient was higher in 1982 due primarily to the Laurentian Channel temperatures being 3 to 5°C below their climatic mean.

The cause of these below normal temperatures is unknown. Accompanying the longitudinal decrease in temperature was an increase in surface salinities and densities (Fig. 14,15). The waters of salinity <30 decreased in volume towards the northwest being limited to the inshore regions off northern Cape Breton Island (Fig. 4-6,8,9,14). Above 47°N the offshore surface salinities over the Magdalen Shallows were 30 to 31 (Fig. 14) and in the Laurentian Channel they were >31, the maximum observed.

Over most of the Magdalen Shallows there was a cold (<2°C) bottom layer below 25 to 35 m which was separated from the surface mixed layer by a high gradient region. The coldest waters (<1°C) were found at the two furtherest offshore stations along transects A and B and at the middle stations along C (see Fig. 4-6). The salinity of this water was 31.5 to 32. In the Laurentian Channel a cold (<1°C) layer with salinities of 32.5 to 33 was found between ~35 and 125 m (Fig. 9,10). Water of similar characteristics was found in the Cape Breton Channel as far west as transect D (Fig. 8) and in the bottom layer over the Magdalen Shallows along transect E (Fig.9).

In the Laurentian and Cape Breton Channels the temperature increased with depth below ~75 to 100 m (Fig. 10). A temperature maximum of 5.5°C occurred at about 250 m below which temperatures again decreased. Near-bottom temperatures (450 m) were slightly below 5°C. The salinity range of these warm, deep waters was between 34 and 35. The deep layer is an admixture of "Labrador" and "Slope Water" and penetrates the Laurentian Channel from the east (Lauzier and Trites 1958). The three-layer structure, i.e. the warm surface layer, the cold intermediate layer and the warm bottom layer, is typical of the deep regions in the Gulf of St. Lawrence during summer (Lauzier and Bailey 1957).

DISCUSSION

The minimum salinities observed in 1982 were found in the surface waters off the eastern tip of P.E.I. and were lower than those in St. Georges Bay by 1 to 1.5 psu. This pattern was similar to that observed in 1981 (Drinkwater et al. 1983). However, in 1981 this low salinity water covered most of the region between P.E.I. and Cape Breton and extended to the northern limit of the observations (~ latitude 46°45') while in 1982 it was confined to an area south of P.E.I. (latitude 46°30'). Although no measurements were obtained west of St. Georges Bay in 1982, the 1981 data suggest that the low salinity water does not arrive via Northumberland Strait but rather comes from the region north of P.E.I. (Drinkwater et al. 1983).

A major difference between the years is the absolute values of the upper-layer salinities. In general the 1981 salinities were lower by 1 to 1.5 psu than those in 1982. Normally at this time of the year salinity is decreasing (Lauzier 1957a) but this seasonal drop cannot account for the observed difference as the 1981 measurements were taken two weeks earlier than those in 1982. The summer salinity of the surface waters over the Magdalen Shallows is directly related to the spring (April to June) discharge from the St. Lawrence River (Lauzier 1957b). Monthly mean discharges rates for the St. Lawrence River system (St. Lawrence, Ottawa and Saguenay Rivers combined) during this period were higher in 1981 by approximately 5% over those in 1982. Perhaps more importantly, the peak discharge in 1981 occurred a month earlier than in 1982. It would seem reasonable to expect that the corresponding decrease in salinity over the Magdalen Shallows due to the effects of this freshwater run-off would also occur one month earlier in 1981. Therefore the lower salinities observed in 1981 were likely due to the combined effect of slightly greater discharge from the St. Lawrence River system

plus the earlier arrival of its influence onto the Magdalen Shallows.

Advection of surface water off the Magdalen Shallows, along the western shore of Cape Breton, and eastward around the northern tip of the island is suggested from the similarity in water properties. This is consistent with the known mean circulation (Bumpus and Lauzier 1965). The flow out of the Gulf appears to be intermittent as the water at transect E is colder and of higher density than further south on the Magdalen Shallows or to the east along the inshore portion of transect F (Figs. 13 and 15). The nearshore water along E appears to be an intrusion of Laurentian Channel water.

The cold subsurface waters observed in the Gulf during summer are remnants of the previous winter's "in situ" cooling (Banks 1966). During winter the waters over the Magdalen Shallows are homogeneous with an historical mean salinity of approximately 31.5 (Budgen 1981). In the deep regions of the Gulf the isothermal layer in winter extends almost to 150 m (Banks 1966). The climatic mean salinity for the layer from 50 to 150 m lies between 32.5 and 33 (Budgen 1981). Therefore, the difference in salinity between the coldest ($< 1^{o}C$) waters over the Magdalen Shallows (31.5-32) and in the Laurentian Channel (32-33) observed in 1982 reflects their localized geographical origins. Variations in the salinity of the cold water layer throughout the Gulf were also found by Lauzier and Bailey (1957). The cold water from the Laurentian Channel with salinities > 32 and densities $\sim 26\ \sigma_t$ units appears to have been advected onto the eastern portion of the Magdalen Shallows and into Cape Breton Channel (Figs. 20 and 21). This is consistent with the inferred residual bottom drift from sea-bed drift recoveries (Lauzier 1967).

Lauzier (1967) also showed an area of covergence of bottom drift near the southeast corner of the Magdalen Islands, indicative of upwelling. However, the

hydrographic data from 1982 showed no evidence of upwelling. This suggests upwelling is not a persistent feature although it may be intermittent.

One of the main goals of both the 1981 and 1982 cruises was to determine if the hydrographic properties observed in St. Georges Bay were representative of the southern Gulf of St. Lawrence. In 1981 the measurements in eastern Northumberland Strait and the southeastern corner of the Magdalen Shallows showed that waters similar to those found in St. Georges Bay were limited nearshore along mainland Nova Scotia and Cape Breton Island (Drinkwater et al. 1983). In 1982 "St. Georges Bay" type water was found over the Magdalen Shallows between latitudes 46.5° and 47°N a region not sampled in 1981. The time scale of this association cannot be determined from a single cruise. It is hoped that future analyses of historical data and satellite imagery will provide information on the temporal and spatial variability of the hydrographic conditions in the region.

ACKNOWLEDGEMENTS

We would like to thank R.W. Sheldon, chief scientist on the cruise as well as the captain and crew of the CSS Dawson for their help and cooperation. We appreciate the assistance of other scientific staff on board Dawson, especially N. Prouse. We acknowledge and thank R.W. Trites and R.W. Sheldon for reviewing the report. Thanks are also due to L. Allen for typing the manuscript.

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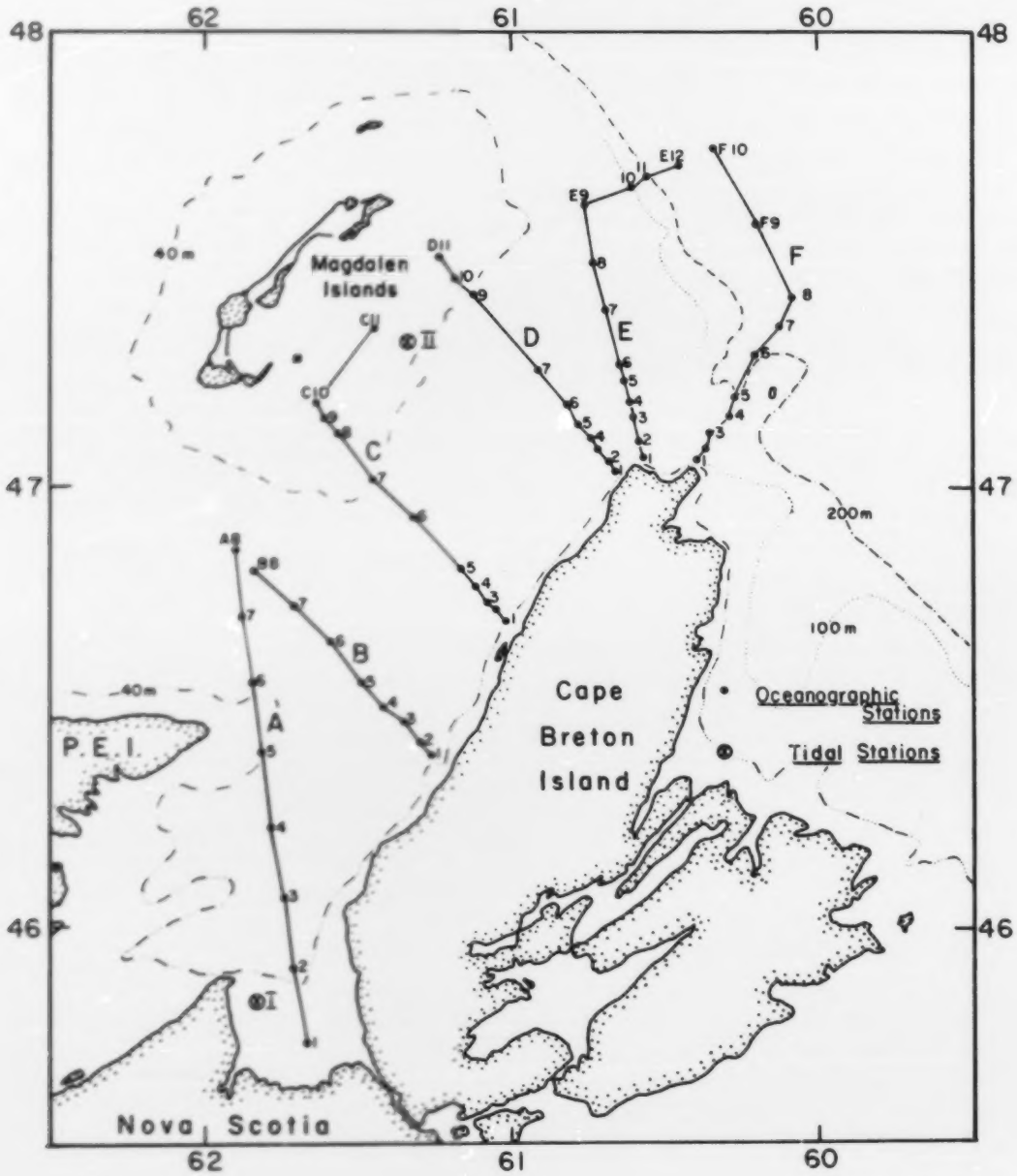

Fig. 1 Southern Gulf of St. Lawrence showing hydrographic stations occupied during 1982 cruise.

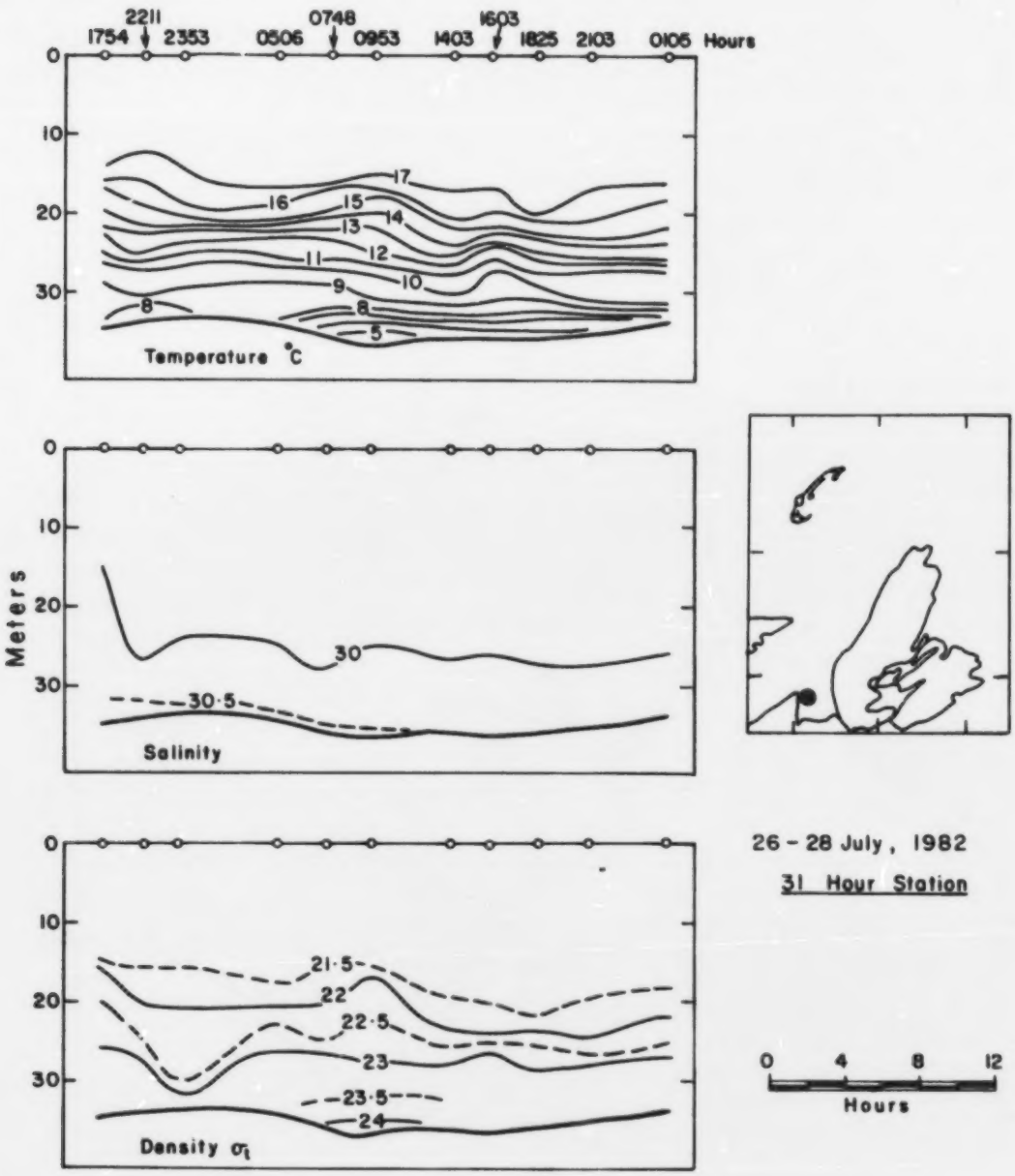

Fig. 2 Time series of temperature, salinity and sigma-t in St. Georges Bay.

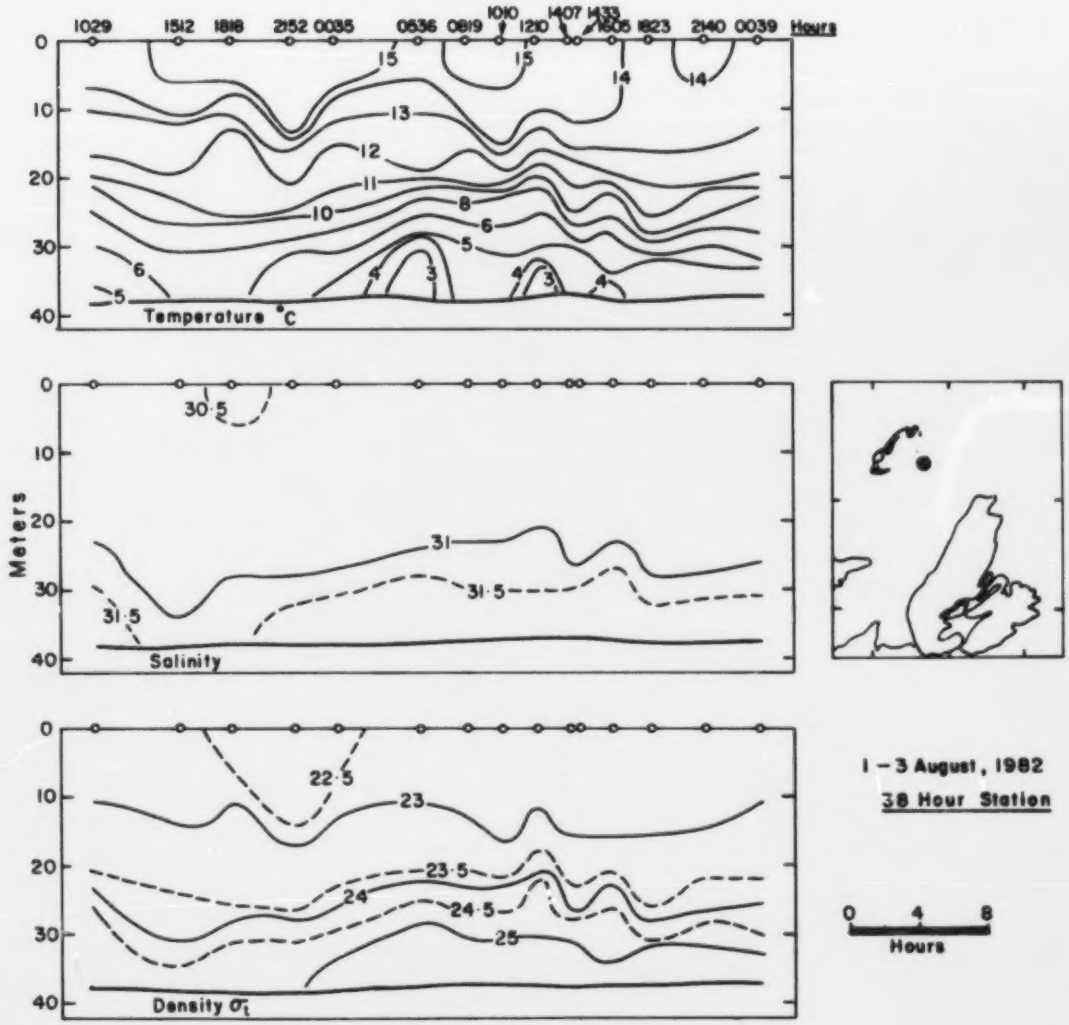

Fig. 3 Time series of temperature, salinity and sigma-t off the Magdalen Shallows.

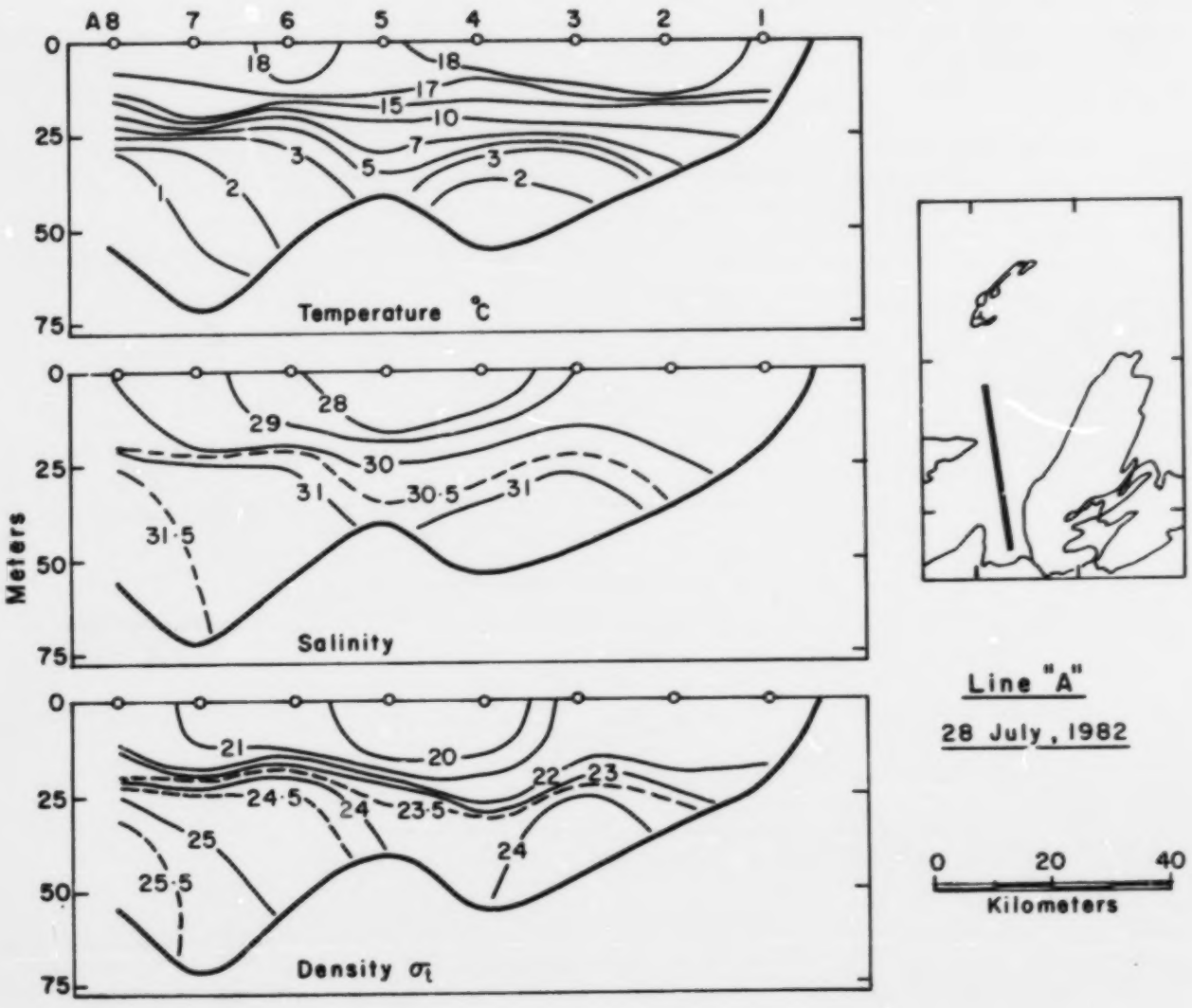

Fig. 4 Temperature, salinity and sigma-t along transect A.

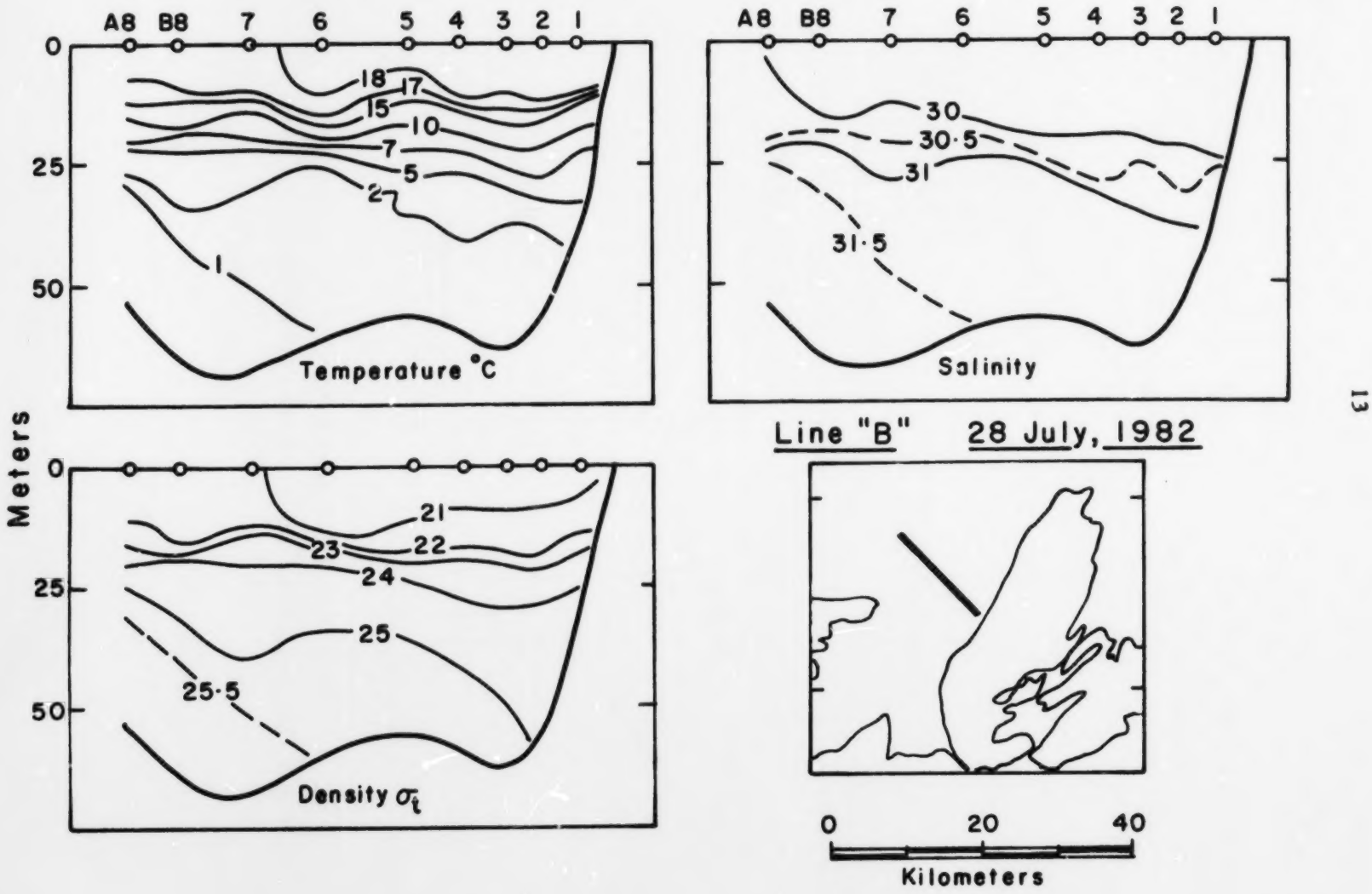

Fig. 5 Temperature, salinity and sigma-t along transect B.

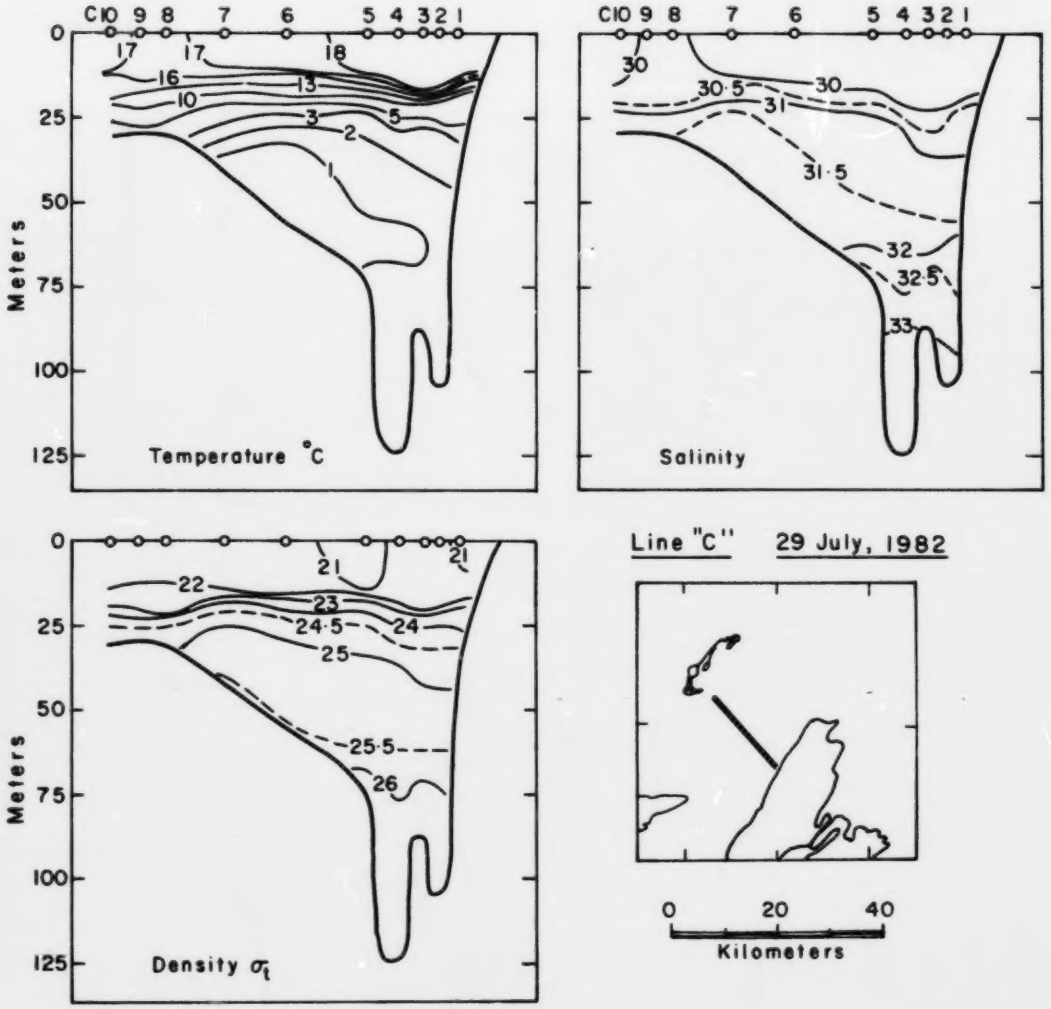

Fig. 6 Temperature, salinity and sigma-t along transect C.

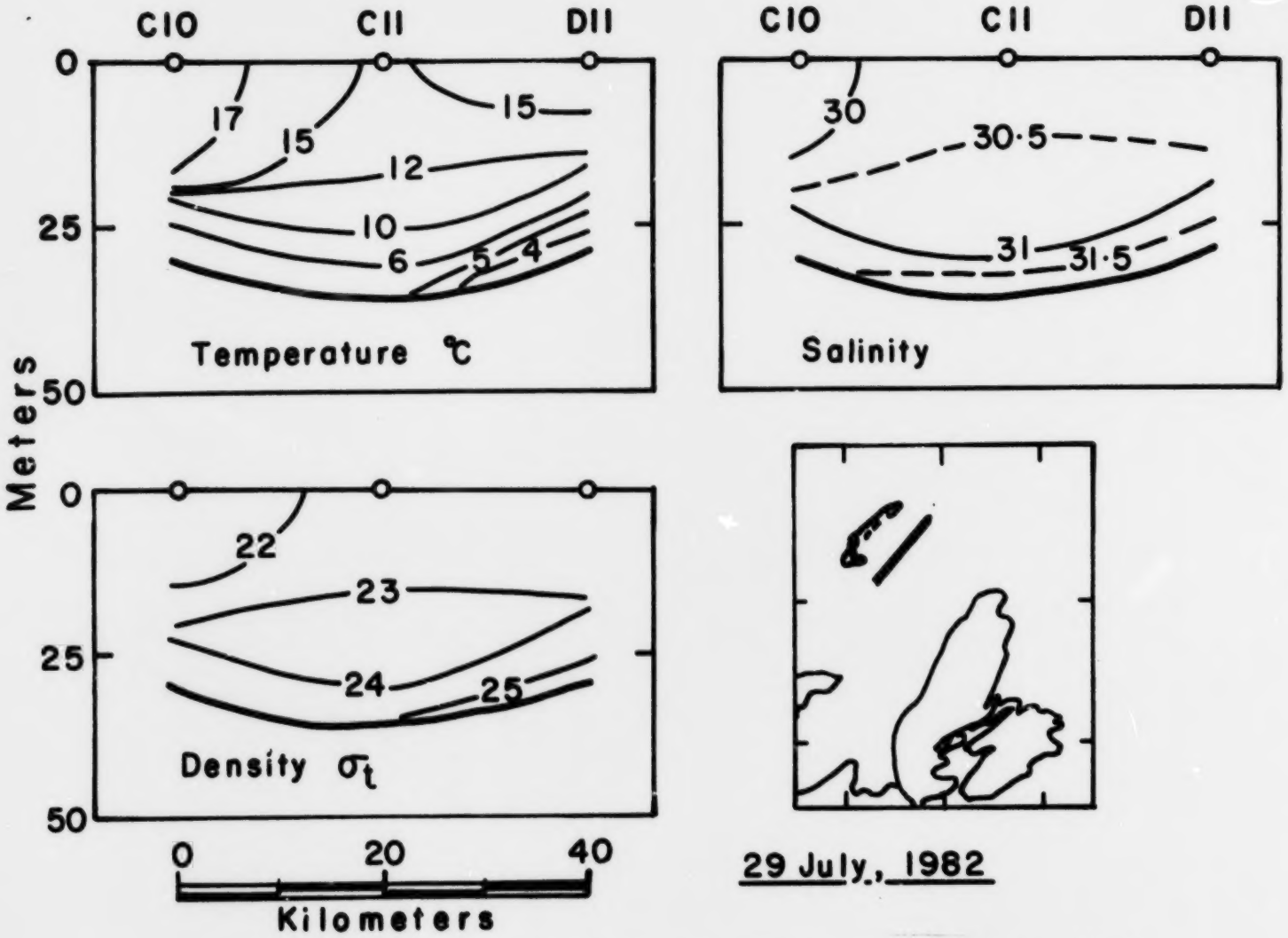

Fig. 7 Temperature, salinity and sigma-t southeast of the Magdalen Islands (Stations C10, C11, D11).

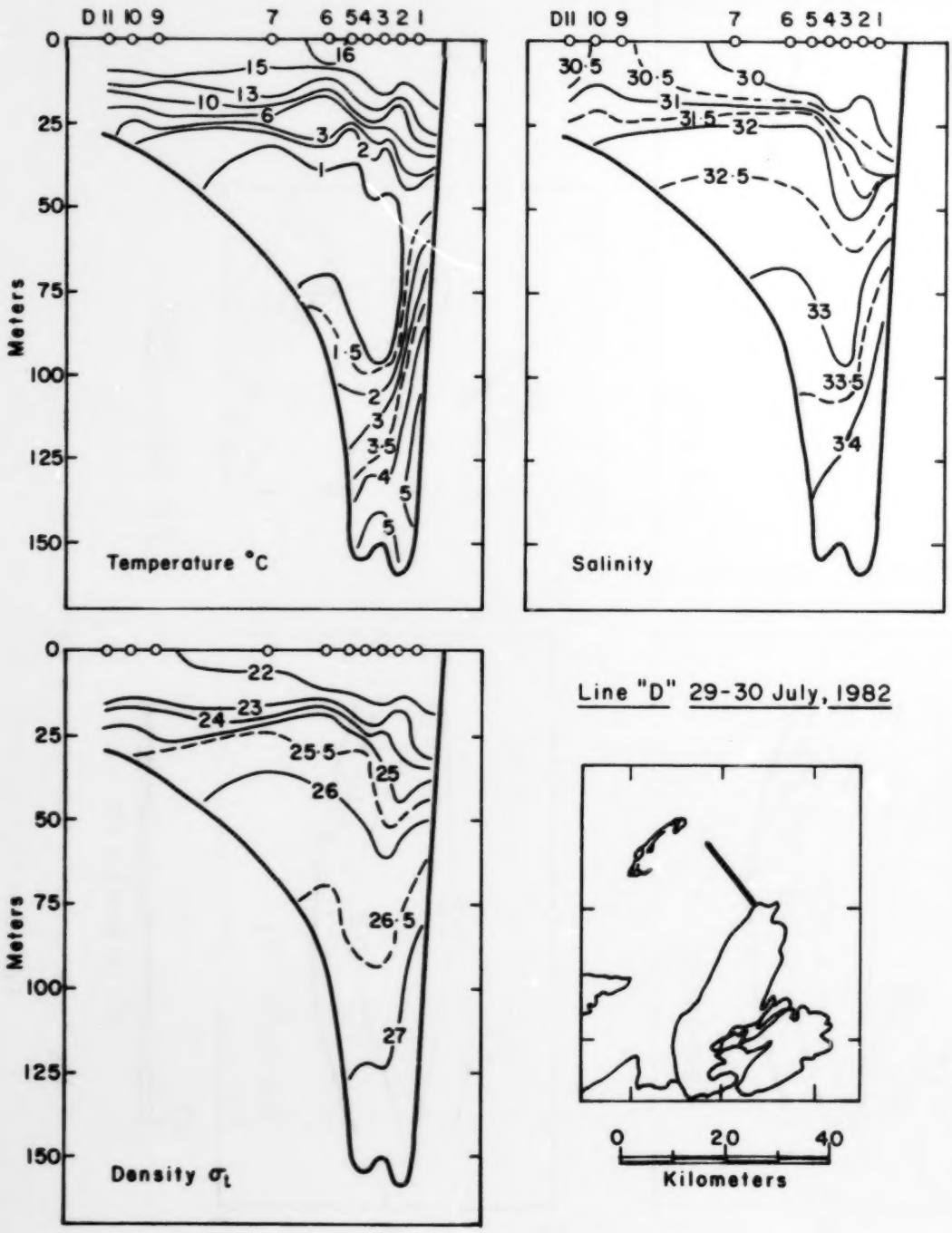

Fig. 8 Temperature, salinity and sigma-t along transect D.

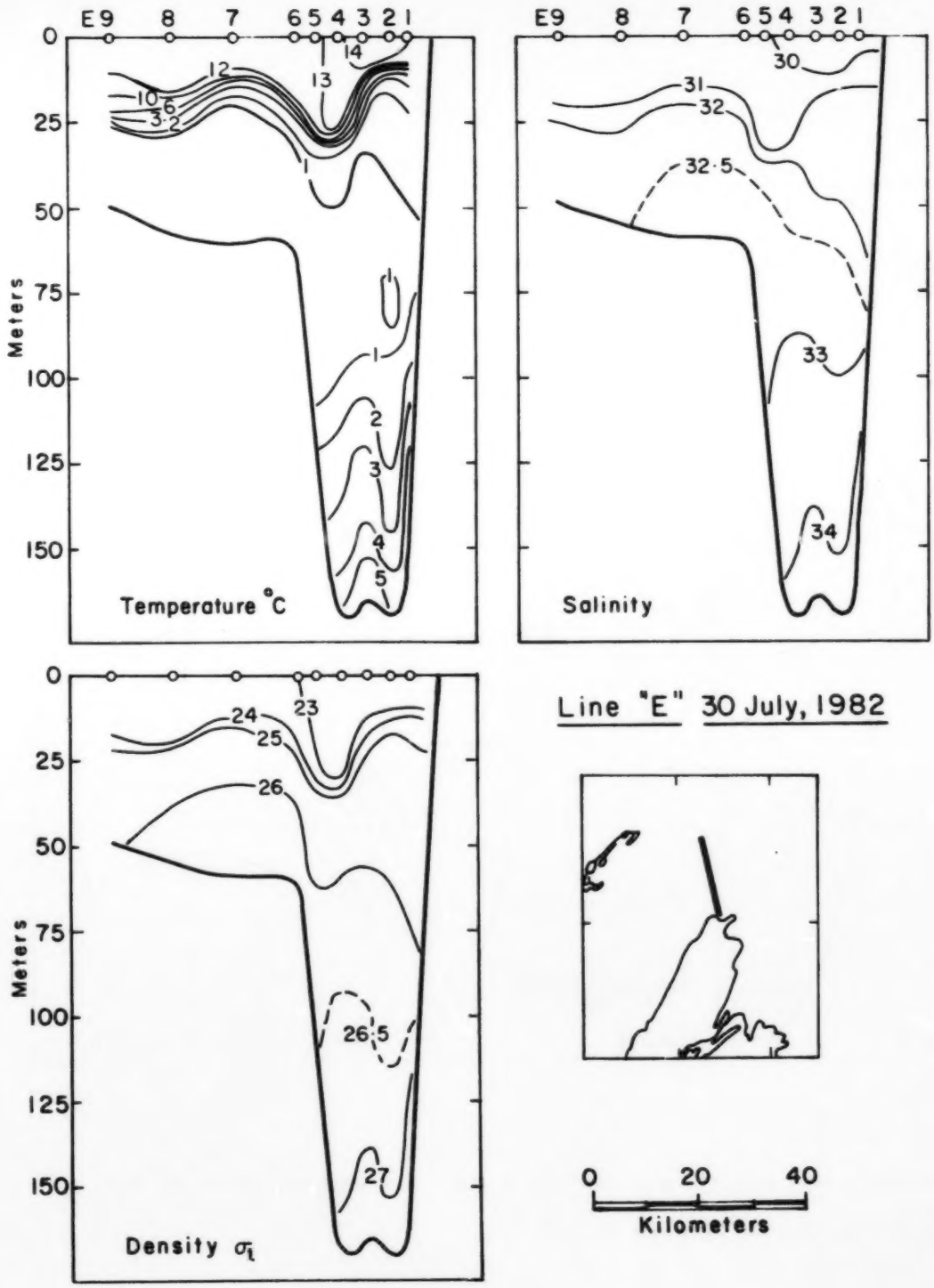

Fig. 9 Temperature, salinity and sigma-t along transect E.

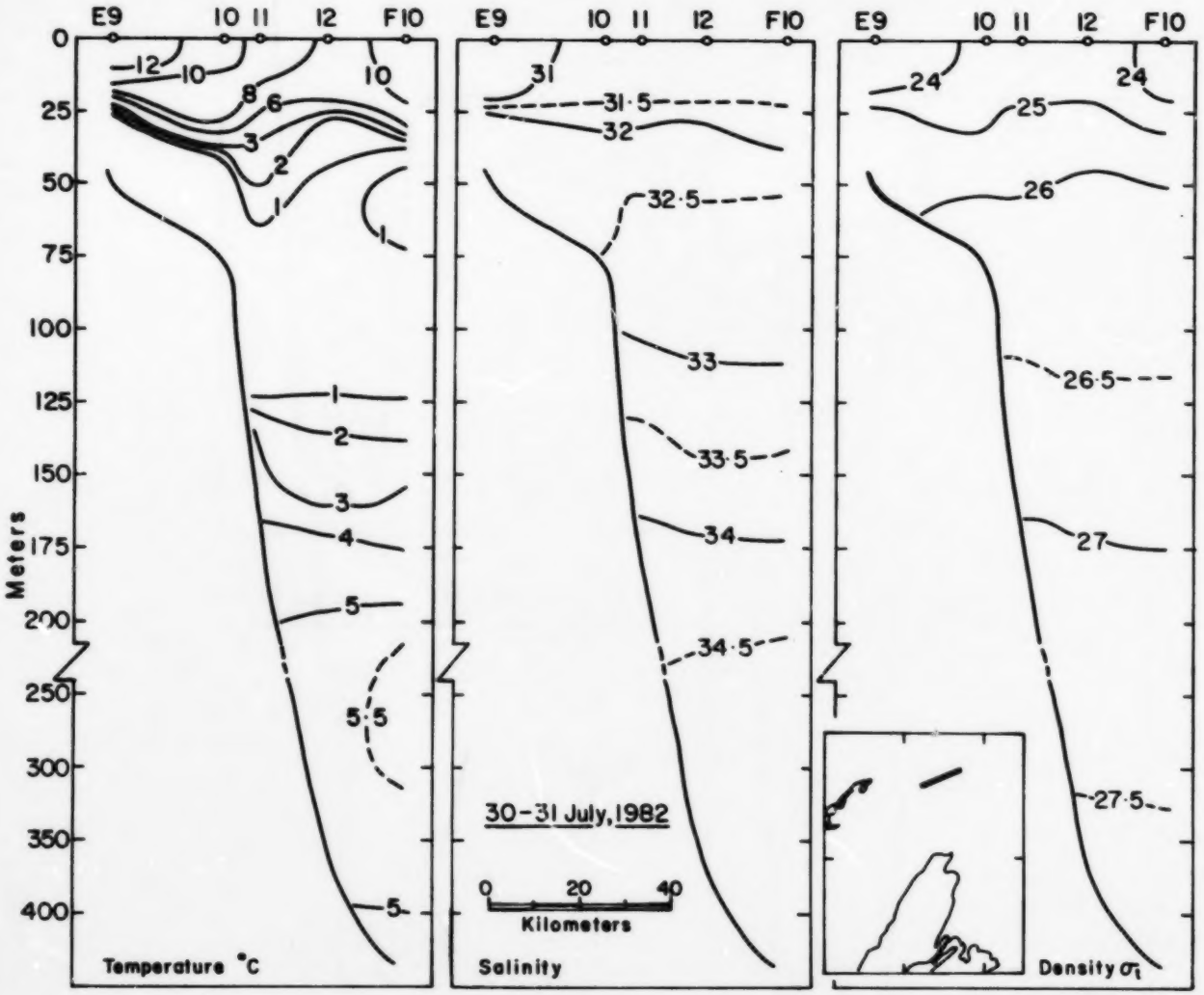

Fig.10 Temperature, salinity and sigma-t across the eastern slope of the Laurentian Channel (Stations E9-E12, F10).

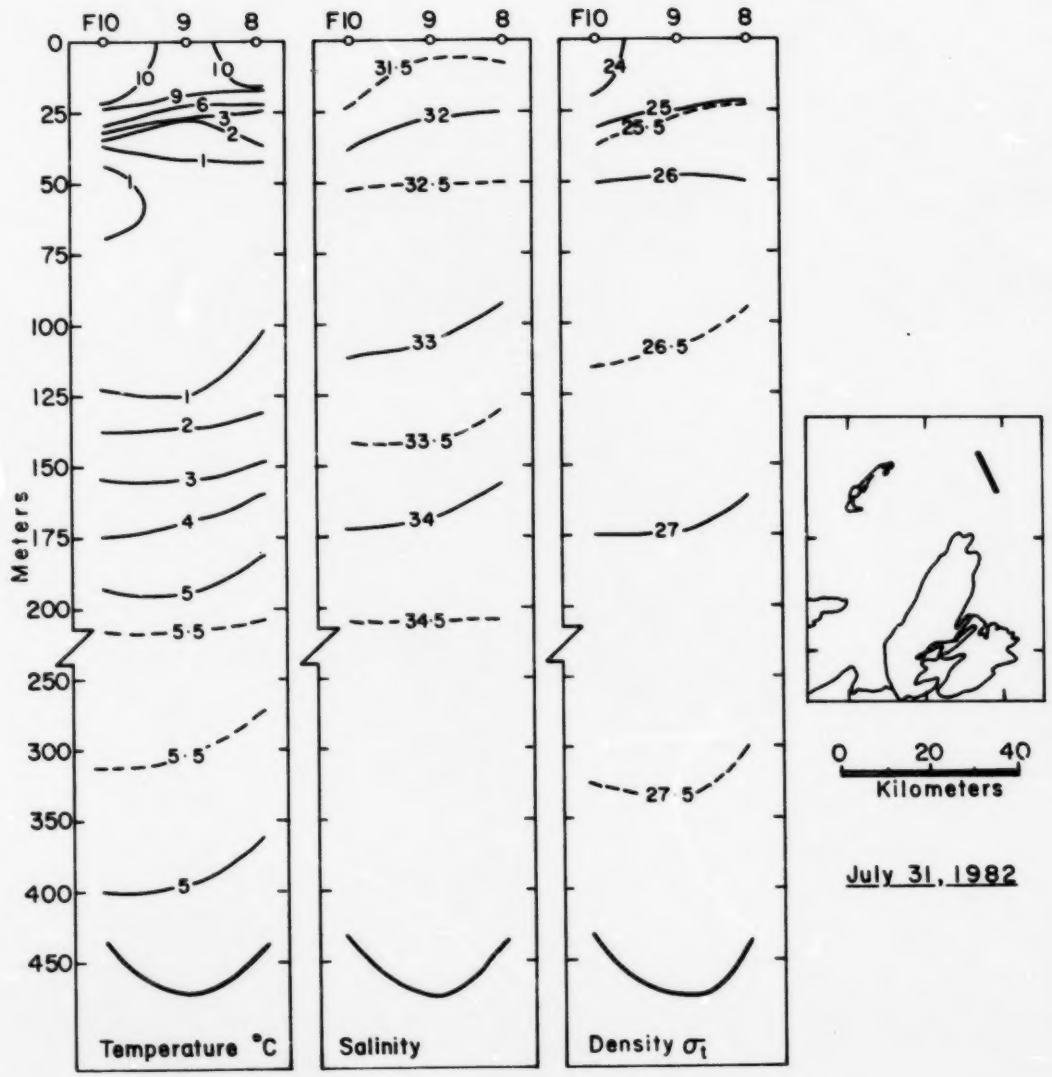

Fig. 11 Temperature, salinity and sigma-t along the Laurentian Channel (Stations F8-F10).

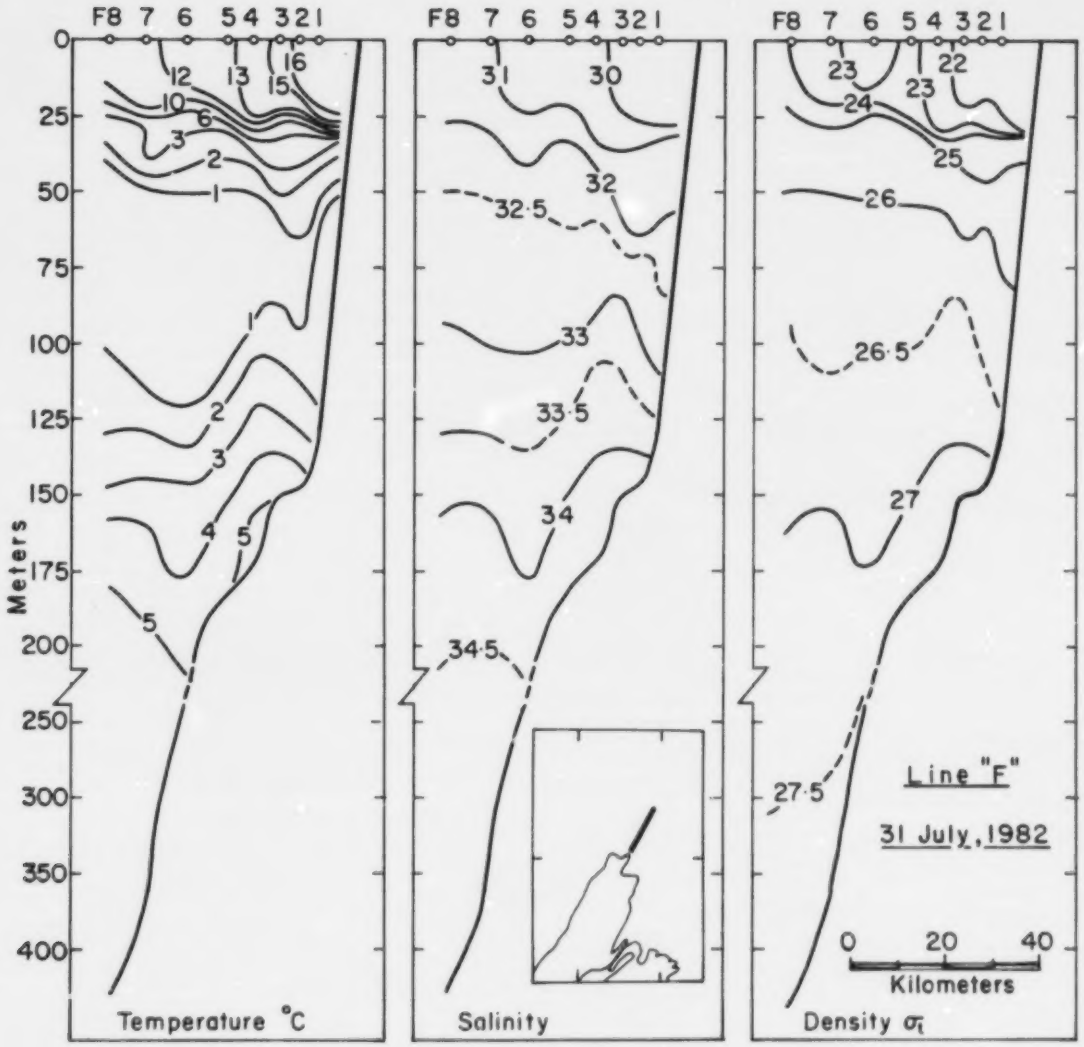

Fig. 12 Temperature, salinity and sigma-t along transect F.

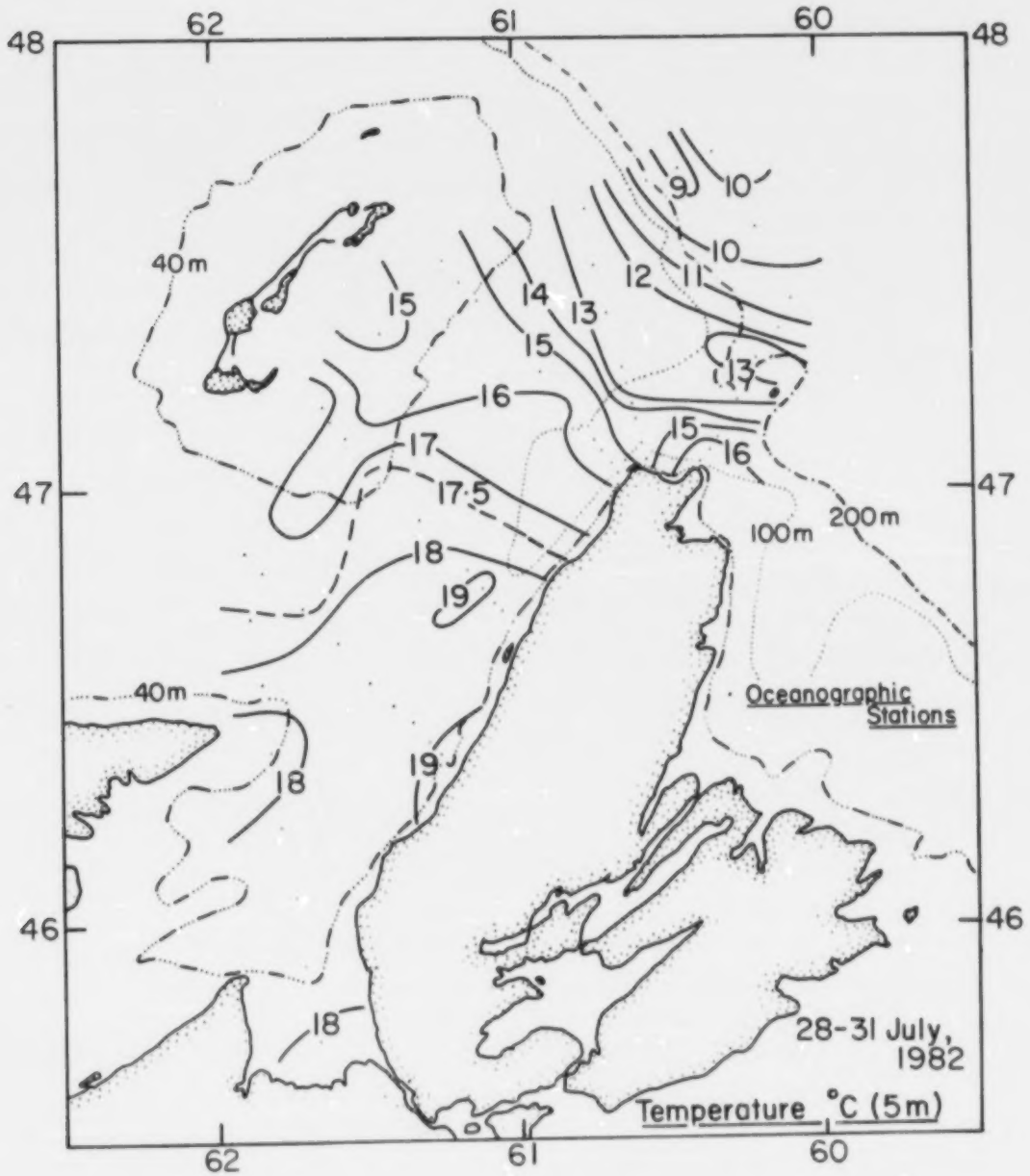

Fig. 13 Temperature at 5 m.

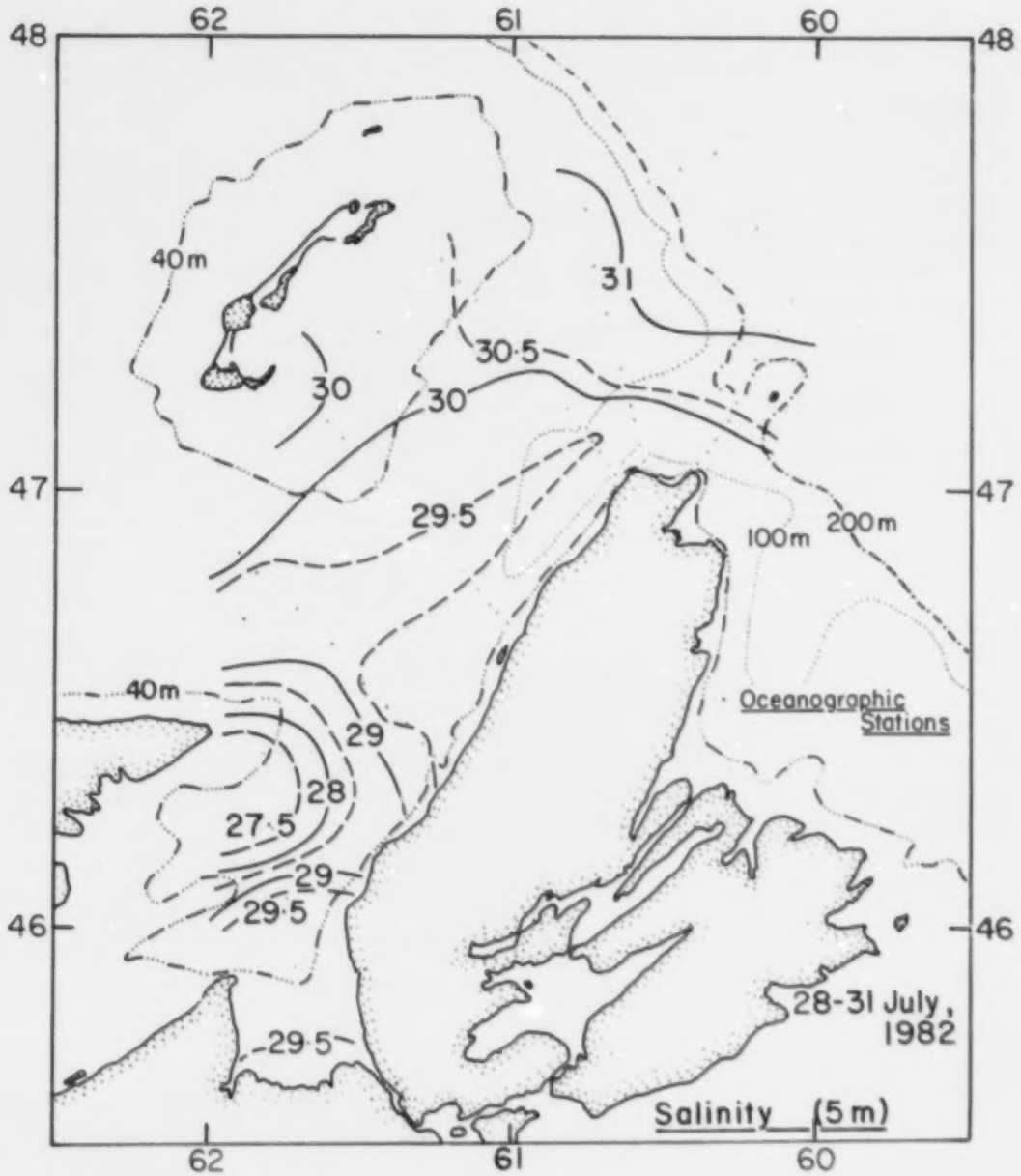

Fig. 14 Salinity at 5 M.

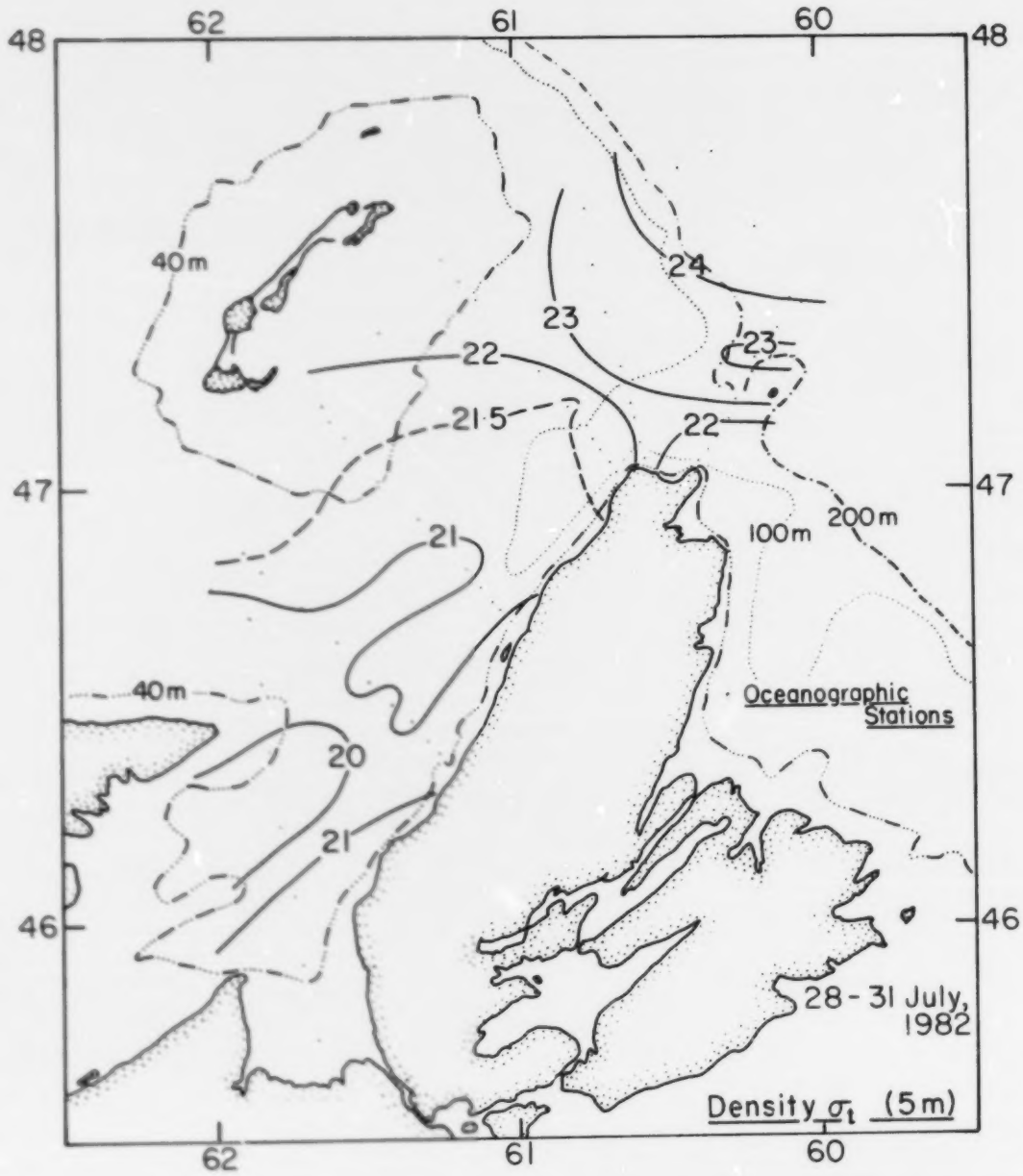

Fig. 15 Sigma-t at 5 m.

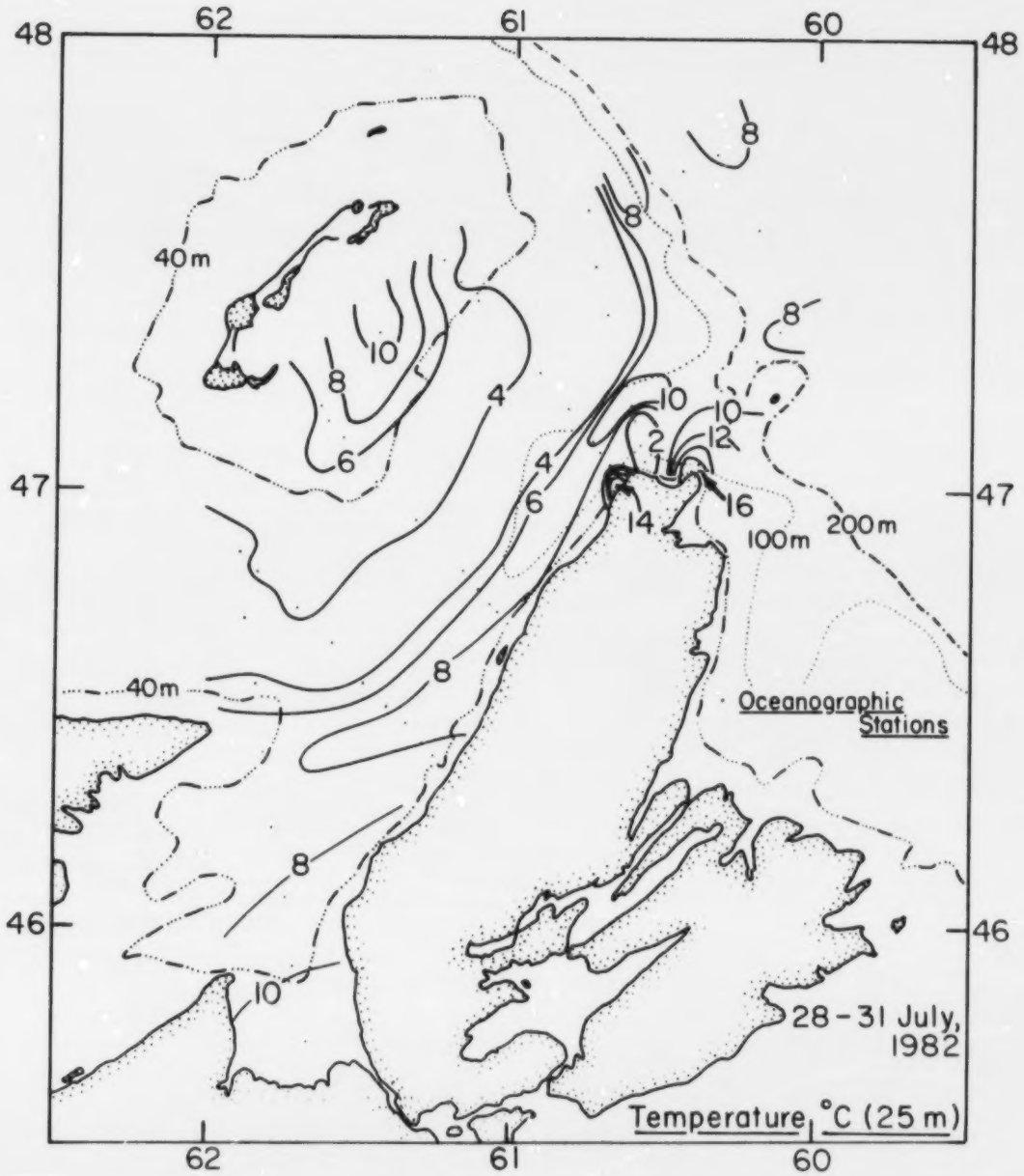

Fig. 16 Temperature at 25 m.

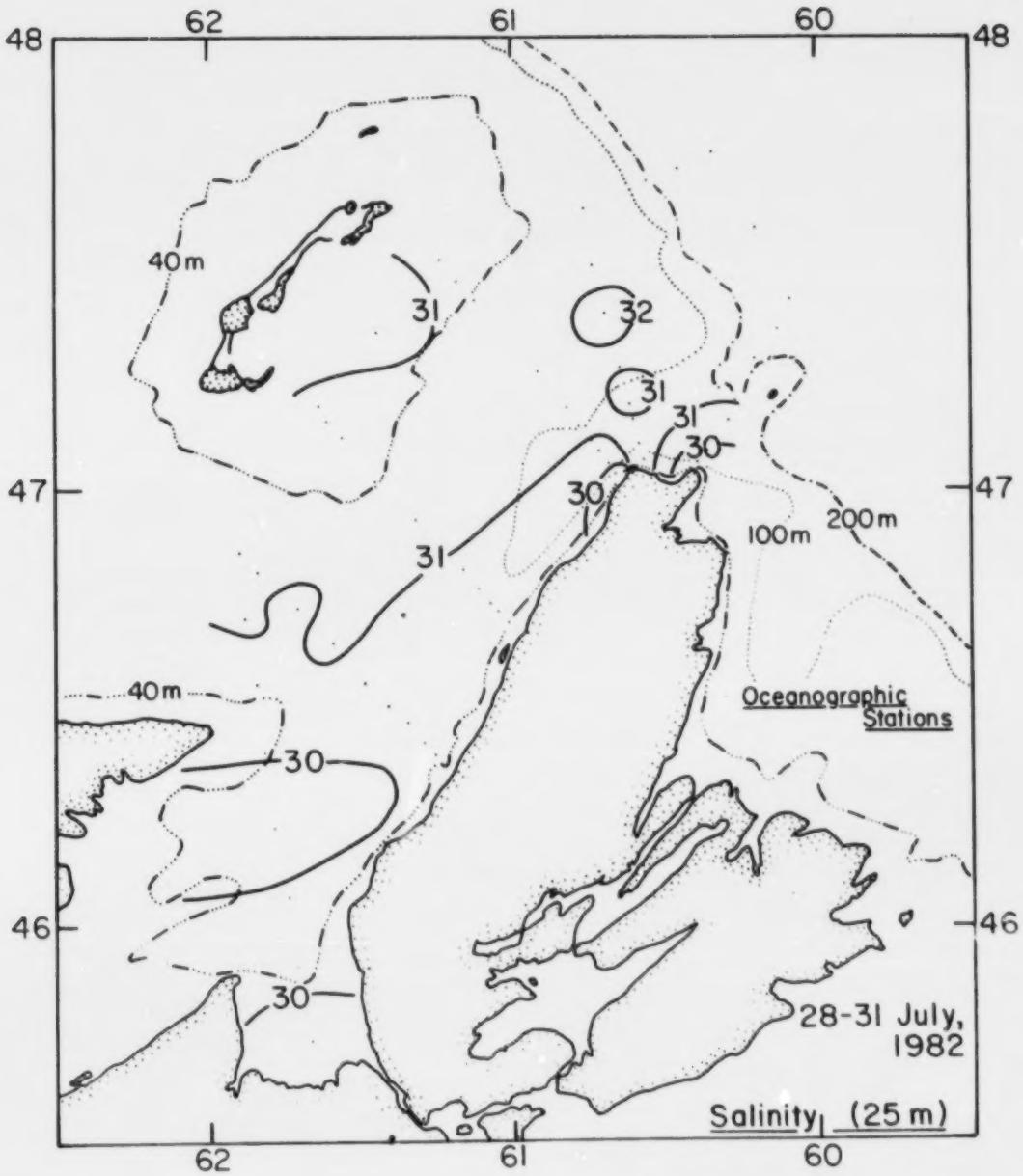

Fig. 17 Salinity at 25 m.

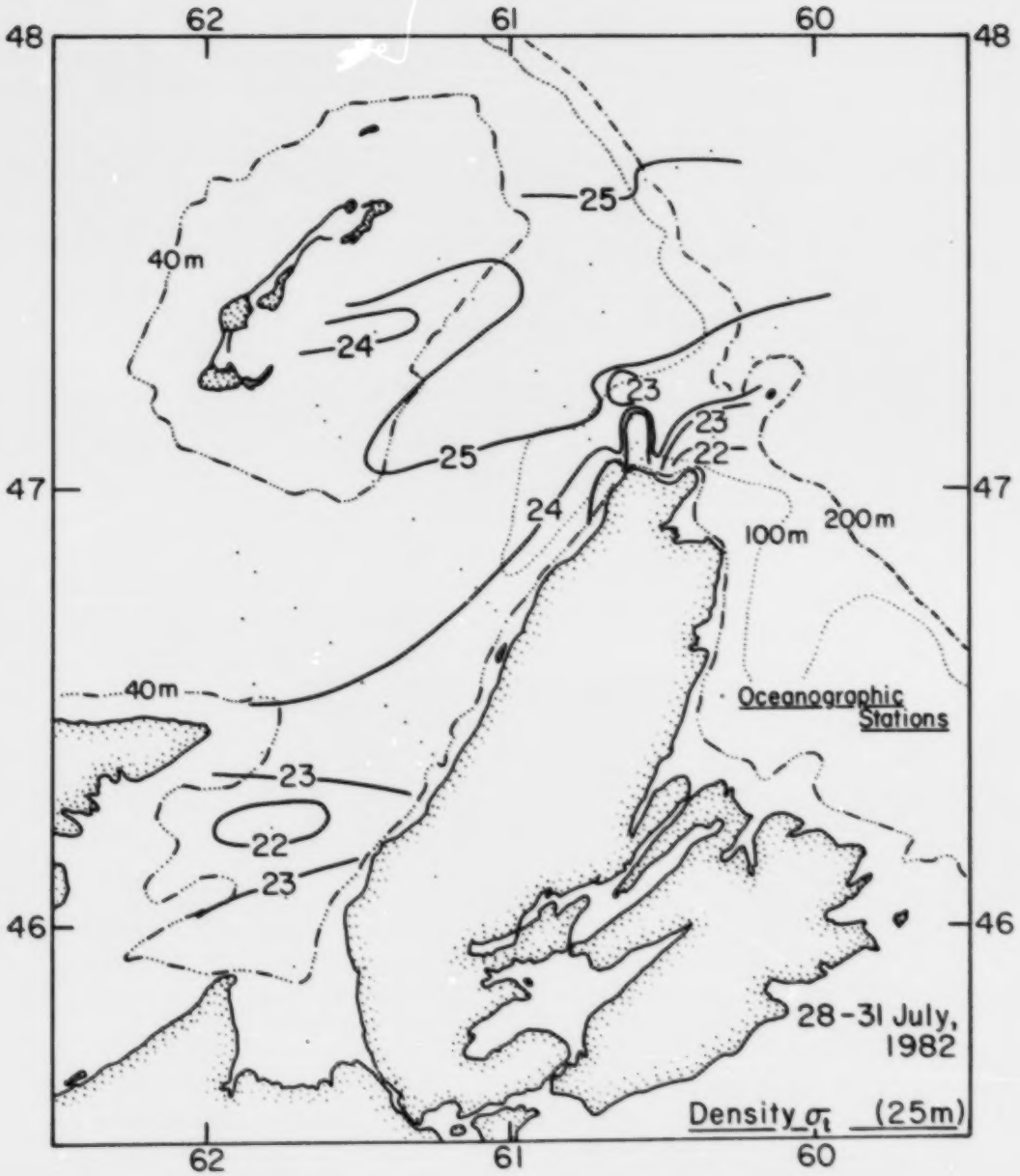

Fig. 18 Sigma-t at 25 m.

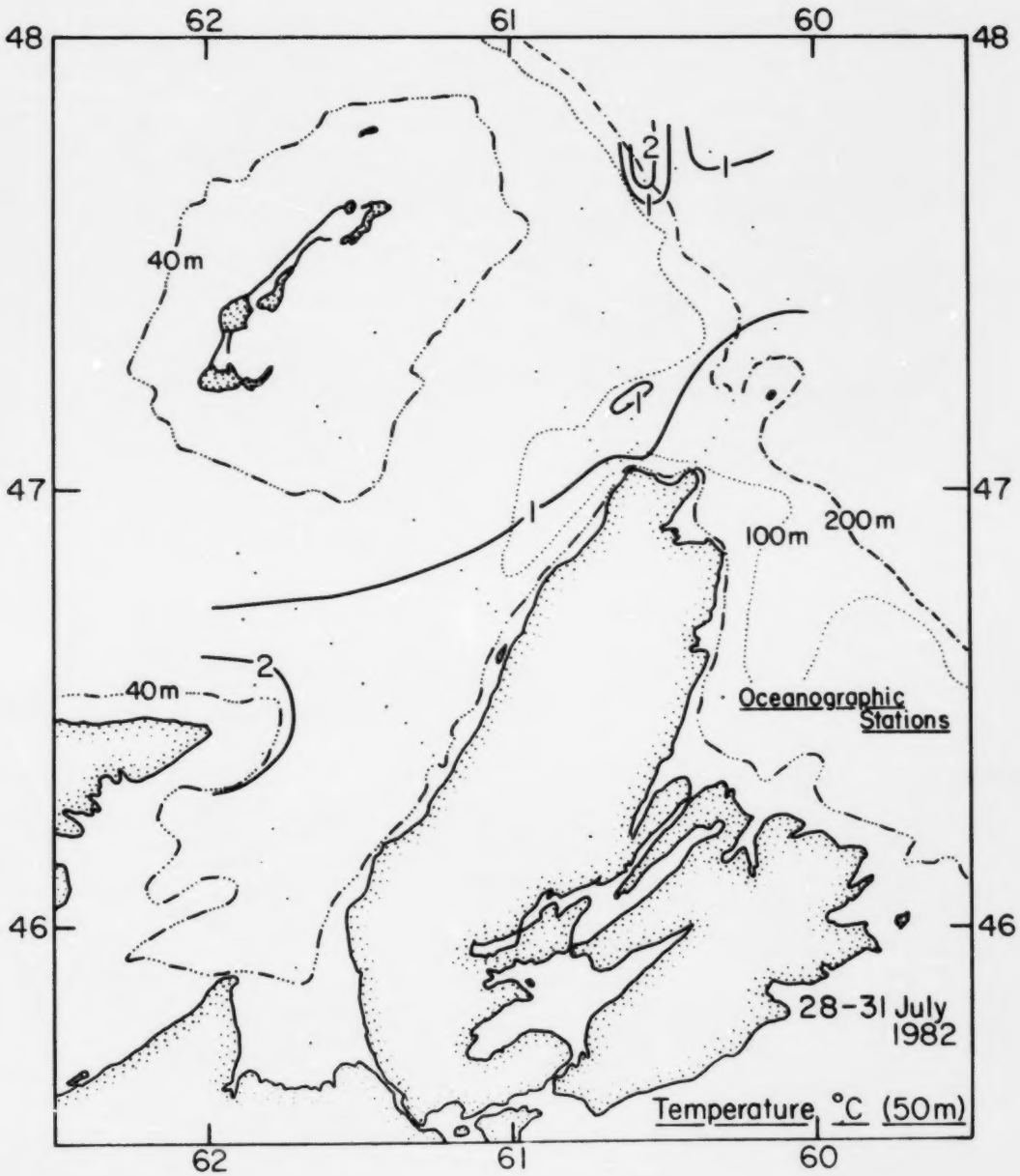

Fig. 19 Temperature at 50 m.

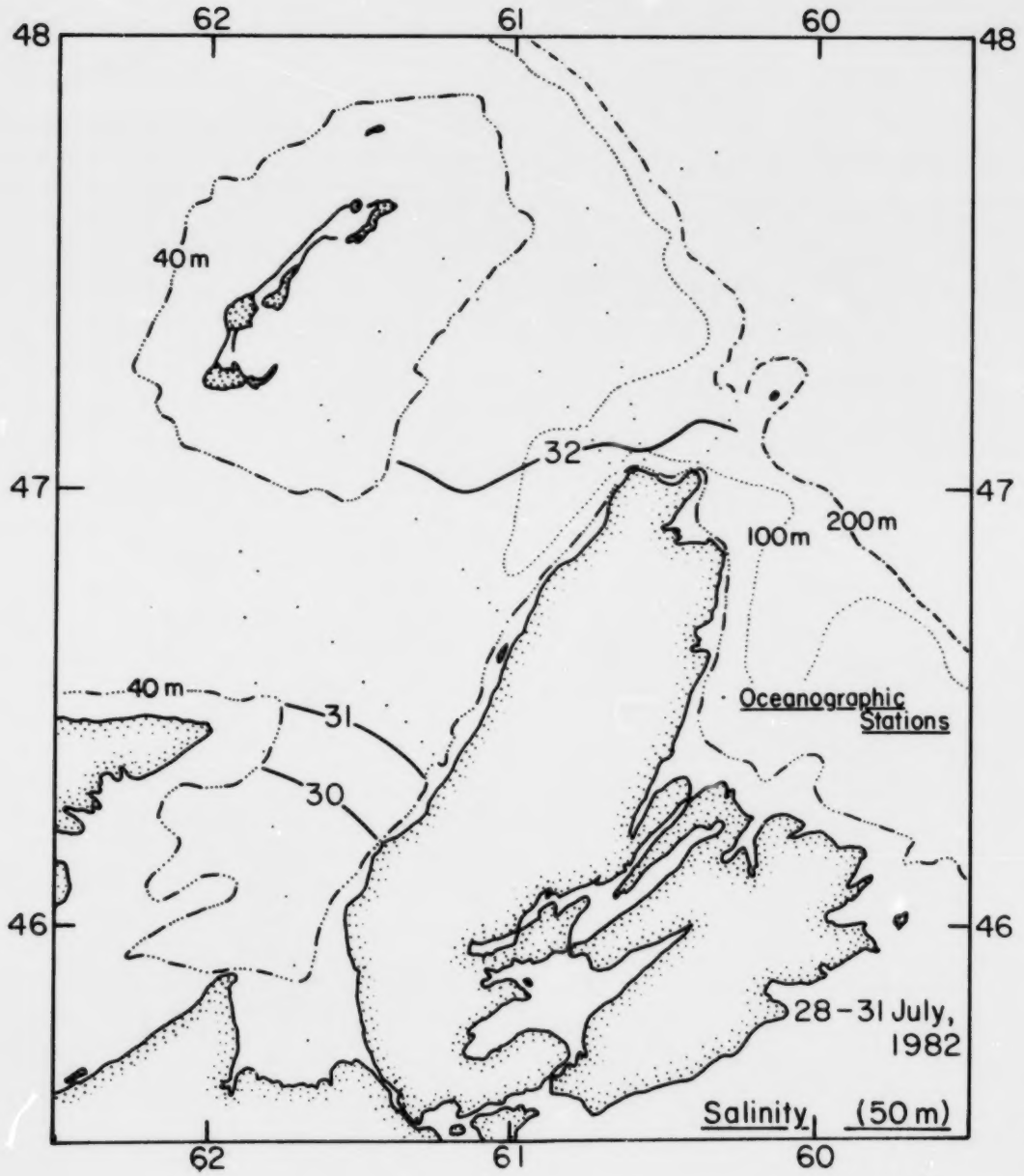

Fig. 20 Salinity at 50 m.

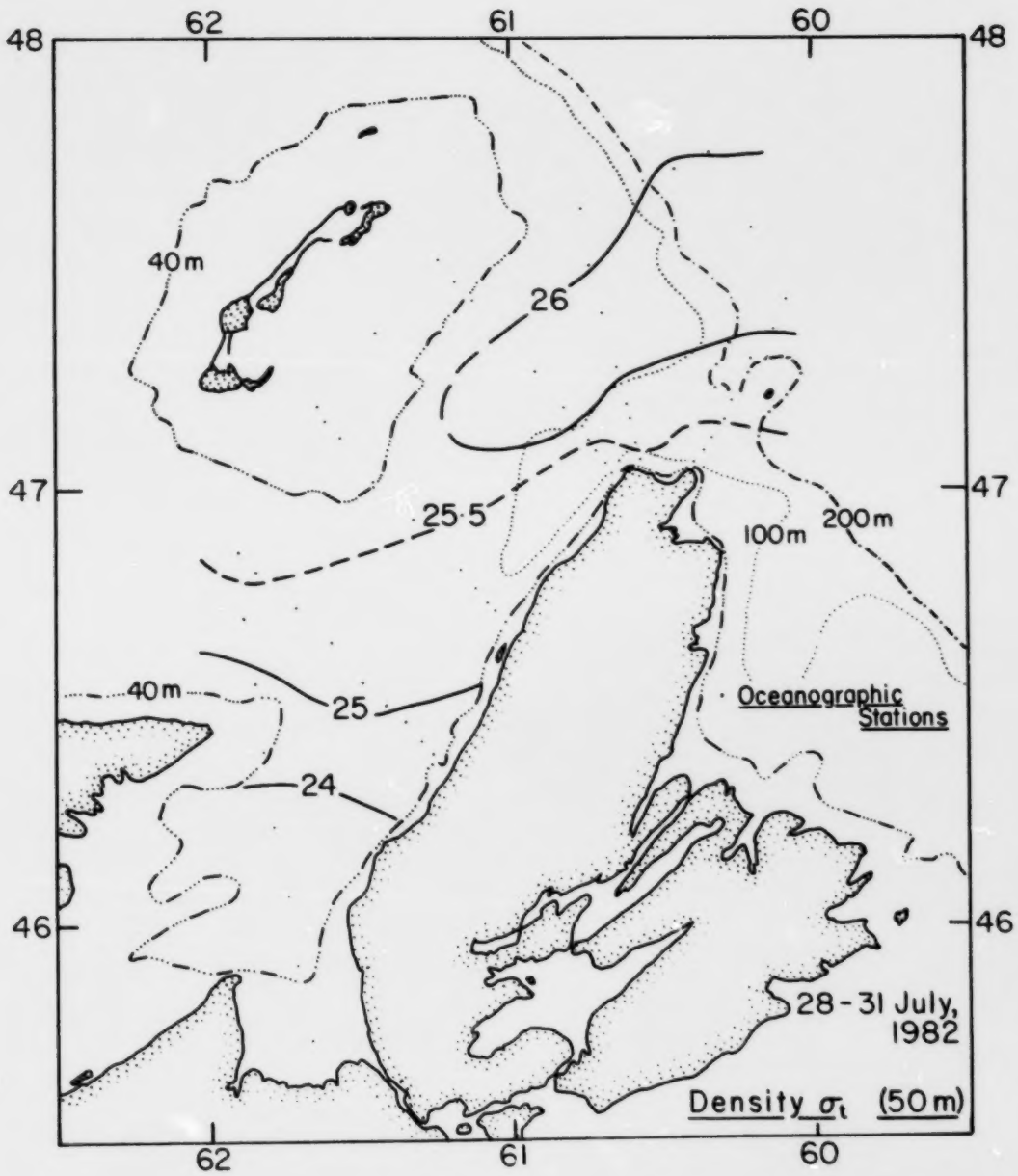

Fig. 21 Sigma-t at 50 m.